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AD-A208 801

DTIC ELECTE JUN 07 1989 D

REPORT DOCUMENTATION PAGE

DTIC FILE COPY

1b. RESTRICTIVE MARKINGS
None

3. DISTRIBUTION/AVAILABILITY OF REPORT
Unlimited

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE
None

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
None Provided

5. MONITORING ORGANIZATION REPORT NUMBER(S)
888840E
TR88-0227

6a. NAME OF PERFORMING ORGANIZATION	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
Tracor Aerospace		General Dynamics/Fort Worth

6c. ADDRESS (City, State, and ZIP Code)	7b. ADDRESS (City, State, and ZIP Code)
Austin, TX 78725	Fort Worth, TX 76101

8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
F-16 SPO	ASD	Contract# F33657-80-G-0007 P.O.# 1005205

8c. ADDRESS (City, State, and ZIP Code)
Dayton, OH 45433

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Phase 2 Final Project Report - Component Testing for Receiving Inspection

12. PERSONAL AUTHOR(S)
Russ Petrie

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 6-1-84 TO 7-1-85	87,07,14	29

16. SUPPLEMENTARY NOTATION
CDRL ITM-004

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	
13	09		Inspection, Component Testing

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This project will enhance and modernize the electronic inspection capabilities of receiving inspection, both to include a reduction in manufacturing test trouble shooting and rework cost and a further enhancement to test and failure analysis capabilities.

This project will implement electronic component/assembly testing at receiving inspection. Cost effective parametric electronic requirements will be established by reviewing specifications/drawings on products being produced and conducting testing time studies.

DISTRIBUTION S...
Approved for p...
Distribution U...

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Captain Curtis Britt	(513) 258-4263	YPTM

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
unclassified

888840E

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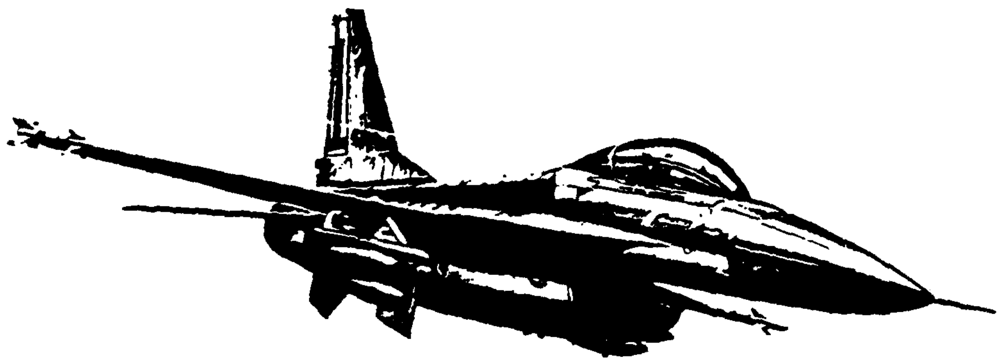
INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM



FINAL TECHNICAL REPORT
CATEGORY 1 PROJECT
COMPONENT TESTING FOR RECEIVING INSPECTION

JULY 14, 1987

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

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Tracor Aerospace

FINAL TECHNICAL REPORT

CATEGORY 1 PROJECT

COMPONENT TESTING FOR RECEIVING INSPECTION

SUBMITTED TO:
General Dynamics Corporation
Fort Worth Division
P. O. Box 748
Fort Work, Texas 76101

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PREPARED BY:

Tracor Aerospace, Inc.
6500 Tracor Lane
Austin, Texas 78725

July 14, 1987

Tracor Aerospace

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OVERVIEW AND PROJECT DESCRIPTION

The Component Testing Project resulted from an analysis of the Receiving and Inspection area. Integrated circuit testing was chosen as a potential opportunity for productivity and quality improvements, in as much as, no integrated circuit component level testing was being performed in Receiving Inspection.

The overall goal of this project was to reduce the amount of factory rework in the assembled circuit card assembly area by detecting potential failures of microcircuits at an earlier and less costly level of inspection. After 18 months of operation the component test system has shown incoming ICs to have an acceptance rate of 99.31% which when applied to the cost or benefit, results in an annual expense of $10,905. Tracor therefore has recommended that the project be removed from further Tech Mod consideration.

1.0 INTRODUCTION

This Final Technical Report is a result of the completion of various investigative stages of the Component Testing Project. This project was chosen as an attractive opportunity for productivity improvements. Earlier research had identified potential cost savings in production test by screening out defective components at the incoming component level instead of the assembled printed wiring board level or system level.

1.1 Component Testing Description

Component Testing as it relates to this project is the process of funtionally testing integrated circuits in accordance with DoD Guidelines (MIL-SPEC-38510, MIL-STD-883) for the purpose of verifying that the purchased lot meets quoted specifications. This verification process can occur at the

vendor's test facilities, at a certified testing house, or at receiving inspection. Prior to this project's Phase 1 investigation, Tracor had to rely on the documentation which the vendor or testing house submitted as proof that the purchased lot met stated specifications.

1.1.1 AS-IS Assessment During Phase 1, Tracor established the AS-IS condition, incoming integrated curcuits were visually inspected for identification, damage and applicable data items. No integrated circuit component level test was performed at Receiving Inspection. Components left Receiving Inspection and were sent to stores where they stayed until kitted for PWB insertion or system level assemblies. During test and/or burn in operations these components were functionally tested. Review of quality records and reports indicated that failed components constituted a major quality driver.

Based on actual charges for the first six months of 1982, total troubleshooting and rework costs (less failure analysis) was approximately $126,000. This equated to approximately 50% of the total workload seen by Manufacturing Test. Stated differently, the cost of fixing failed components (labor plus components costs) was equal to 6 percent of the total cost of touch labor (hands-on labor).

Failed components have several sources. Some are bad when they arrive at Tracor and are accepted because of the Acceptable Quality Level (AQL) sampling plan. Others are damaged in storage, some during production on the shop floor, and some due to improper packaging and handling. No estimates are available on the proportions from each source, but in aggregate they are clearly a quality driver. Eliminating all sources of failed components (admittedly an impossibility) could achieve savings approximating 6 percent of the total touch labor costs.

1.1.2 <u>TO-BE Assessment</u> Working from the premise that cost savings could be achieved in production test by screening out defective components at receiving inspection, Tracor setout to develop equipment requirements and specifications which would satisfy the need. The test equipment was to originally address the following families:

Bus Bars	Integrated Circuits
Capacitors	Opto Devices
Circuit Breakers	Oscillators
Couplers	Regulators
Counters	Resistors
Crystals	Switches
Diodes	Transformers
Filters	Transistors
Fuser	<u>All Assemblies</u>
Inductors	

Once installed into receiving inspection, the equipment would cost effectively process and detect potential failures associated with these families before placing them into stores or in PWB, SRU, or LRU Assemblies.

2.0 PROJECT DESCRIPTION

The objective for the Component Testing Project was to validate our premise that production test cost could be reduced by screening components at Receiving Inspection. During this development phase several ideas concerning component testing and component test equipment were discussed and evaluated. Early discussions with similar electronic companies on feasibility and practicality of testing all the component families presented in Section 1.1.2 resulted in a change of project scope. Screening cf integrated circuits, both CMOS and transistor-transistor logic (TTL) devices was viewed by industry as having the only payback potential since these devices carry a high purchase cost.

2.1 Preliminary Design

2.1.1 Industry Survey An application assessment was conducted on the proposed component families. A survey of electronic companies similar to Tracor was conducted to determine the feasibility of testing all listed components. An assessment was also made on commercially available and off-the-shelf equipment to determine the cost-to-benefit of testing all components in the proposed family. The result of our findings (shown in Table 1) indicate that integrated circuits with their embedded opts devices, oscillators, regulators and switching logic; and transistors as they apply to transistor-to-transistor logic devices are the only components which can be cost effectively screened at Receiving Inspection.

2.1.2 Preliminary System Analysis To define the system requirements, all functional parameters relating to ICs (both CMOS and TTL devices) had to be identified. The project team reviewed a sample size of these components and from this determined the functional parameters and preliminary equipment requirements. These system requirements were then reviewed by Reliability Engineering and Design Engineering for applicability

FAMILY	Industry Tested		Cost-To-Benefit Ratio			COMMENTS
	YES	NO	LOW	MED	HIGH	
Buss Bars		x	x			
Capacitors		x	x			
Circuit Breakers		x	x			
RF Couplers	x			x		
Counters		x	x			
Crystals		x	x			
Diodes	x			x		
Filters		x	x			
Fuses		x	x			
Indultors	x			x		
Integrated Circuits	x				x	
Opto Devices	x				x	Opto devices currently embed-ed into integrated circuits
Oscillators	x				x	Oscillators currently into integrated circuits
Regulators	x				x	Regulators currently embedded into integrated circuits
Resistors		x	x			
Switches	x				x	Switched such as gate arrays & logic switch devices
Transformers		x	x			
Transistors	x				x	Transistor-transistor logic devices

Table 1 - INDUSTRY SURVEY - Result Of Early Investigation Led To Rescoping Of Project To Include Only Integrated Circuits

to any preceived requirements which may be forthcoming in newly designed components. Table 2 is the result of the preliminary system analysis which formed the bases for detail equipment specifications.

2.2 Final Design

2.2.1 Equipment Specifications Equipment Specifications were prepared for the IC tester and IC handler; terminal and printer specifications were developed under a separate Tech Mod project. These specifications were distributed to sixteen IC test vendors and eight IC handler vendors. A trade analysis was later performed using their responses and associated product literature (See Figures 1 and 2). Reliability Engineering then ranked each vendor according to capability and cost. The Siemens 725 tester and Trigon Model 2070 handler won their respective categories. Based on this technical evaluation, Purchasing placed the orders. See Appendix A for additional supporting data.

2.2.2 Design Integration Scope of the project was such that major integration of hardware was not practical. The development team however did plan for the automatic transfer of Inspection Result (IR) data into Tracor's quality data base via AFI-Quality System.

2.2.3 CBA Data Cost baseline for the Component Testing Project is founded upon "cost avoidance". Without the use of an IC tester the impact on manufacturing would be the rework of PCB, SRU, and LRU assemblies which had faulty components. Studies were conducted from 1986 actuals and produced the following data:

- Annual Pieces Inspected 312,028
- Defective Components 2,157
- Percent Defective 0.69%
- Operator Cost $59,592
- Cost Avoidance $48,687

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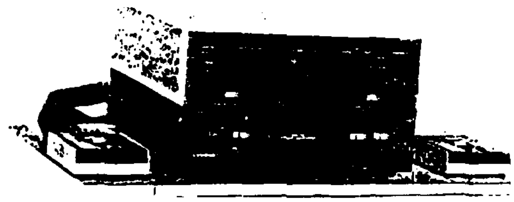
COMPONENTS SAMPLED		TYPE IC		FUNCTIONAL PARAMETERS													
Vendor	NUMBER	CMOS	TTL	a	b	c	d	e	f	g	h	i	j	k	l	m	n
SGS	M38510/00903 BCB		x	x	x		x	x	x	x		x		x	x		
FC	M38510/00105 BCB		x				x	x	x	x		x		x	x		
MO	SNJ54LS151V		x	x			x	x	x	x			x				
FC	M38510/30003 BCB		x				x	x	x	x			x		x		
FC	4070BDMOB	x		x			x			x	x			x		x	
MO	M614508BALD	x		x			x			x	x			x		x	
TI	SNG 5432J		x														
TI	SNG 54LS174J		x	x			x	x		x			x				
*AMD	AM27513DC			x	x							x					
NSC	DM746574AN/A		x				x	x	x	x			x		x	x	
NSC	M38510/30502BCX		x	x			x	x		x			x				
TI	SNC 54LS00J		x				x	x	x	x			x		x		
RCA	ST67191-4013	x		x			x	x	x	x	x		x		x		
SGS	N825181N	x		x	x	x	x	x	x	x	x		x				
SPS	M38510/05504BEX	x		x			x	x	x	x			x				
FC	M38510/30106BEX		x				x	x	x	x		x		x	x		
SSS	M38510/05201BCX		x	x			x	x		x	x		x				

*EPROM

a) Power (current at various input voltages)
b) Shorts (at each input pin)
c) VIL/VIH (voltage input low/high at each input pin)
d) IIL/IIH (input current low/high at each input pin)
e) VIK (clamping voltage-all pins)
f) VOL/VOH (voltage output low/high at each output pin)
g) Truth table-functional test performed at various VCC)
h) IOL/IOH (current output low/high at each output pin)
i) KELV (open contacts at each input pin)
j) IOSH/IOSL (current output short high/low)
k) VDP/VDN (voltage delta positive/neg)
l) ICCH/ICCL (current supply)
m) VOLA/VOLB (voltage at output low/high)

Table 2 IC FUNCTIONAL PARAMETERS - Thirteen Functional Parameters Identified For Testing

Handler

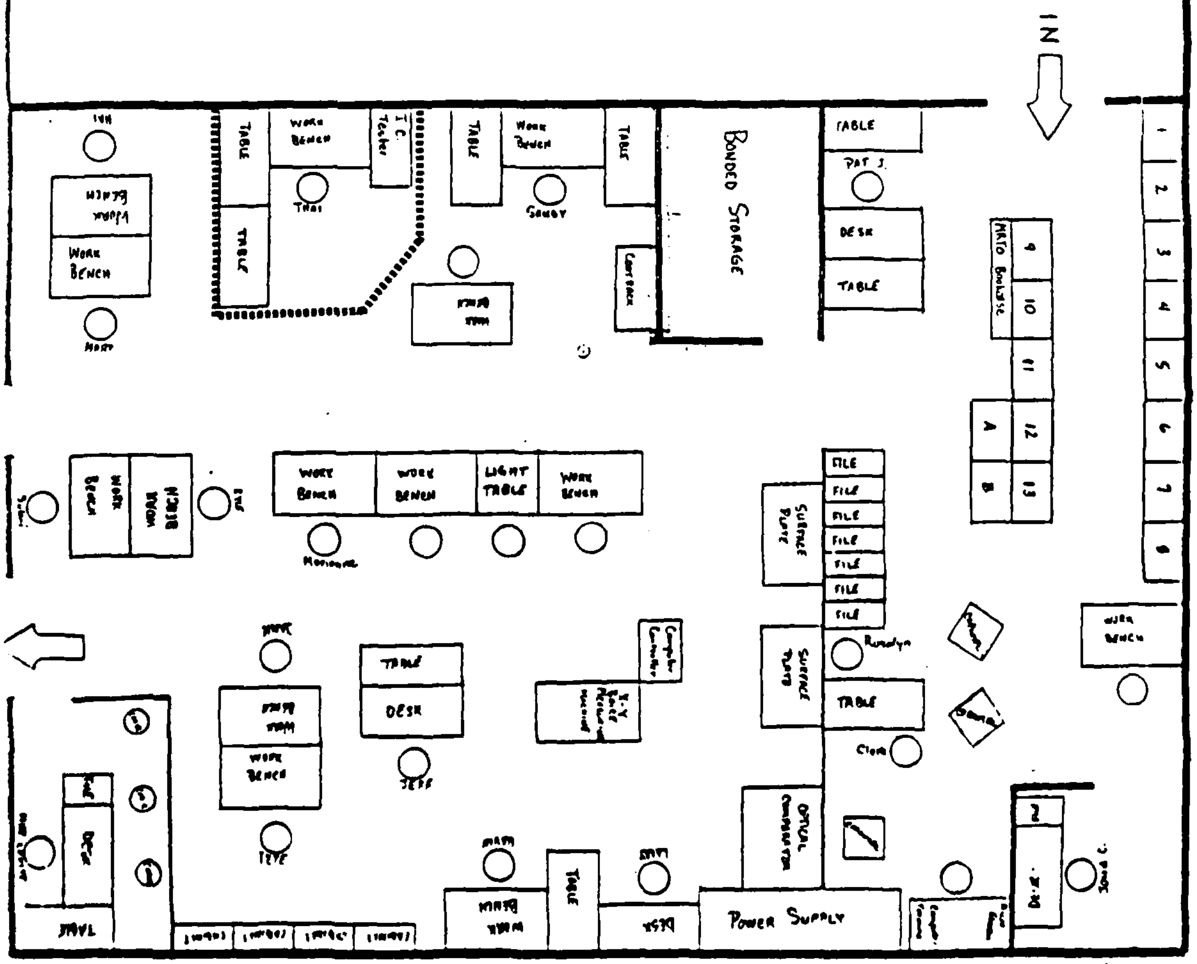


IC Tester

Terminal

Printer

RECEIVING INSPECTION
COMPONENT TEST EQUIPMENT



I.C HANDLERS REVIEWED	No. of IC Load Bins	Bin Sorting	Temp Capability	Ease Of Setup & Operation	Ease Of Repair	Field Tech. Support	Max No Device Pins	Device Size/Adjustable	Supplier Stability	Wide Industry Acceptance	Relative Cost	Comments
Daymark Model 952/3	2	Yes	Amb	-	-	Yes	36	No	-		Mod	New product, limited data
Model 1152	2	Yes	Amb	Good	Fair	Yes	48	No	-	Yes	High	
Model 1156/57	2-20	Yes	Hot/Cold	Good	Cmplex	Yes	40	No	-	Yes	High	
Delta Model 8040	1-25	Yes	Hot/Cold	Good	Good	Yes	42	Yes	0	Mod	High	
Exatron Model 800B	1	Yes	Amb	Good	Good	No	6-40	Yes*	+	Yes	Low	*Multipackage Handled but not Adjustable
Model 810C	1	Yes	Hot	Good	Good	No	6-40	Yes*	+	Yes	Low	*Multipackage Handled but not Adjustable
Model 2500	2	Yes	Amb	Good	Good	No	40	No	+	Yes	Low	
MicroComponent Technology Model 2608E	Bulk	Yes	Not	Fair	Fair	Yes	40	Self-Adj.	+	Yes	High	Relatively expensive hardware Less flexible setup. Complex mechanism
Model 260AC	Bulk	Yes	Cold	Cmplex	Fair	Yes	40	"	+	Yes	High	One of the few cold handlers/LN_2
Model 3608AE	Bulk	Yes	Hot	Fair	Cmplex	Yes	8-42	"	+	Yes	High	Higher speed hot handler
PAE Model 3000	2	Yes	Hot	Good	Fair	No	36	No	-	Low	Low	
Symtek Model 7191ND	2	Yes	Hot/Cold	Fair	Fair	No	32		0	Mod	Mod	
Trigon Model 2070	3	Yes	Hot	Good	Good	Yes	24-48	Yes	+	Yes	Low	Very easy to setup and use.

Figure 2 IC HANDLER TRADE-OFF ANALYSIS - Seven Vendors Evaluated Against Technical Requirements, Trigon Model 2070 Selected.

2.2.3.1 Installation and Equipment Cost Construction In Process (CIP) used to install the desk top size and standard plug-in receptacle equipment resulted in zero dollars. CIP however was used to perform the following:

- o Training
- o Writing Test Programs

Total cost for these items for 1984 and 1985 was $6,785 and 17,946 respectively.

Equipment cost and other capital are shown below:

o	Siemens 725 (P.O. 702290)	$ 55,545
o	Trigon Handler (P.O. 702289)	$ 22,212
o	Calibration/Backup Tapes (P.O. 702614)	$ 7,942
o	Other (P.O. 417709, P.O. 836016)	$ 324
	TOTAL	$ 86,023

2.3 Factory Implementation

Purchase orders for the Siemens Tester and Trigon Handler were released in the 2nd Quarter 1984 and equipment was installed into Receiving Inspection in August 1984. Figure 3 shows the off-the-shelf equipment purchased and it's placement into Receiving Inspection. No facility modifications were required since it was only necessary to rearrange several work benches and tables.

2.3.1 Implementation Impacts During the initial 8 months several problems occurred which prevented the system from achieving maximum benefit. Miscommunications between Siemens and Tracor delayed the receipt of calibration and backup test program cassette tapes until February 1985. During a factory training session an electronic assembly was found defective and was returned to the factory for repair. In June 1985 the operation was interrupted for two weeks due to mechanical and electrical problems in the Trigon handler.

I C TESTERS REVIEWED

	Digital	Analog/Linear	Memory	Microprocessors	Software Cost	Device Software Library	Ease Of Use	Need Dedicated Prof. Staff	Field Tech Support	Reliability/Repairability	Max No. Device Pins	Supplier Stability	Interface W/Handlers	Calib/Self Test Modes	Batch Memory/Reports	Multi-User Test Heads	DC Parametrics	AC Parametrics	Data Log Printout	Accuracy	Wide Industry Acceptance	Relative Cost	Comments
Analog Devices LTS-2000	Yes	Some	No	No	Low	Yes	Good	1	Yes	Good	24	+	Yes	Yes	Yes	No	Yes	No	Yes	Mod	Low-Mod	Mod	
LTS-2010	Yes	Some	No	No	Low	Yes	Good	1	Yes	Good	24	+	Yes	Yes	Yes	No	Yes	No	Yes	Mod	Low-Mod	Mod	Relatively easy to setup and use
LTS-2015	Yes	Some	No	No	Low	Yes	Good	1	Yes	Good	24	+	Yes	Yes	Yes	No	Yes	No	Yes	Mod	Low-Mod	Mod	
LTS-2500																							
AED/Critic	Yes	No	Yes	No	Low	Yes	Good	No	No	Un-known	16-24	-	Yes	Yes	No	No	Yes	No	No	Low	Low	Low	Parametrix measurements are limited
Datatron Spectrum Series 1	Yes	No	Some	Some	Low	Yes	Good	1	Yes	Good	16-48	+	Yes	Yes	Yes	No	Yes	Yes	Yes	Mod	Low	Mod	
Exatron Model 510	Yes	No	Yes	Yes	N/A	N/A	Good	No	No	Good	16	0	Yes	Yes	No	No	No	No	No	Low	Low	Low	Tests using signature analysis
Model 2800	Yes	No	Some	Some	N/A	N/A	Good	No	No	Good	28	0	Yes	Yes	No	No	No	No	No	Low	Low	Low	" " "
Eagle Test Systems Model LS-1	Yes	Some	Some	Some	Mod	Small	Cmplex	Yes	No	Fair	60	-	Yes	Yes	No	No	Yes	Some	Yes	Fair	No	Mod	Very difficult to setup and use
Fairchild Sentinal	Yes	Yes	Yes	Yes	High	Yes	Cmplex	Yes	Yes	Excel	30-60	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Very High	Yes	Very High	Fairchild systems are
Series 20	Yes	Yes	Yes	Yes	High	Yes	Cmplex	Yes	Yes	Excel	60	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	the standard against
Model V	Yes	Yes	Yes	Yes	High	Yes	Cmplex	Yes	Yes	Excel	30-60	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	which most other
Model VII	Yes	Yes	Yes	Yes	High	Yes	Cmplex	Yes	Yes	Excel	32+	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	are judged
Model VIII	Yes	Yes	Yes	Yes	High	Yes	Cmplex	Yes	Yes	Excel	120	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	Very powerful, expensive.
GenRad Model 1731	No	Yes	No	No	Low	Yes	Excel	1	Yes	Good	16	0	Yes	Yes	Yes	No	Yes	No	Yes	Mod	Mod	Mod	Relative easy to setup & use.
Model 1732	Yes	No	Some	No	Mod	Yes	Excel	1	Yes	Good	16-48	0	Yes	Yes	Yes	No	Yes		Yes	Mod	Mod	Mod	" " "
Model 1734H	No	No	Yes	No	Low	Yes	Excel	1	Yes	Good	16	0	Yes	Yes	Yes	No	Yes	Yes	Yes	Mod	Mod	Mod	" " "
Model GR-16	Yes	No	Yes	Yes	Mod	Yes	Excel	Yes	Yes	Mod	144	0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High	Mod	Very High	Very complex & powerful system
Hewlett-Packard Model 5045A	Yes	No	Some	No	Mod	Yes	Mod	Yes	Yes	Excel	16-24	+	Yes	Yes	Yes	No	Yes	No	Yes	Good	Low-Mod	low	Operation not difficult but setup and programming
System 5046A	Yes	No	Some	No	Mod	Yes	Mod	Yes	Yes	Excel	16-24	+	Yes	Yes	Yes	No	Yes	No	Yes	Good	Low-Mod	Mod	require skilled staff
MicroComponent Technology Model IT-200	Yes	No	No	No	Low	Yes	Good	1	Yes	Good	48	+	Yes	Yes	Yes	No	Yes	No	Yes	Good	Yes	Mod	Relatively easy to setup & use.
Model 2000	Yes	No	Some	No	High	Yes	Mod	Yes	Yes	Good	14	+	Yes	Yes	Yes	No	Yes	Yes	Yes		Yes	High	" " "" "
Semiconductor Test Technology Model EMT-200	No	No	Yes	No	N/A	No	Mod	1	No	Fair		-	Yes	No	No	Yes	No	No	No	Mar-ginal	No	Low	Limited test sophistication Low cost memory testor/ Not suitable for non-tech op.
Siemens Model 725	Yes	No	Some	No	Very Low	Yes	Good	1	Good	Good	24	+	Yes	Yes	Yes	Yes	Yes	No	Yes		Yes	Low-Mod	Relatively easy to setup & use Very stable, very accurate.
System Sales Model LSI-1	Yes	No	Yes	Yes	High	Small	Mod	1	No	Fair	28	-	Yes	Yes	No	No	Yes	Yes	Yes	Fair	No	Low	An ambitious but unproven low cost tester.
Teradyne Model J325	No	Yes	Some	No	Mod	Some	Mod	Yes	Yes	Good	14-28	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Very Good	Yes	Very High	Analog test system, laser trim tests
Model J385A	No	No	Yes	No	High	Yes	Cmplex	Yes	Yes	Good	24-72	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	High speed RAM test system
Model A360	No	Yes	No	No	High	Yes	Cmplex	Yes	Yes	Good	24-72	+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	"	Yes	"	Analog test sys. Very powerful.

2.3.2 Summary of Findings The Siemens component tester has had no significant impact on reducing rework or repair cost at board or assembly level testing. Tracor's original hypothesis was that many vendors were shipping substantial quantities of defective components, which resulted in prohibitive rework and repair during manufacturing test. This hypothesis now appears to be erroneous.

During 1986 Receiving Inspection 100% inspected 940 lots which contained 390 different components (e.g., TTL, CMOS, memory devices, etc.), and 312,028 piece parts. The Siemen tester interrogated each piece part and found only 2157 defective components. Figure 4, Panel A, graphically depicts the monthly accepted quantities and the number of corresponding defects. Panel B shows the breakout by vendor, and also shows that three of the twelve vendors delivered no defective components for 1986. Monthly reports of Military Specification ICs manufactured by Motorola, National Semiconductor, RCA and Siliconix were submitted to DCASMA and showed that rejection rates of these devices ranged from .37% to 0.20%. The average of 0.69% defective for Tracor's IC vendors, though exceeding the desired 0.37% defect rate, is within generally acceptable limits.

2.4 Cost Benefit Analysis

A detailed cost benefit analysis was made to document the anticipated savings to be accrued by implementation of the Component Testing Project. Studies were conducted by taking actual parts tested in 1986 on the Siemens 725 Integrated Circuit Tester and the expenditures were computed by comparing parts failure rate in Receiving Inspection to the parts failure rate in Component Level Test.

- In 1986, 940 lots of 312,028 integrated circuits were tested and 2,157 integrated circuits were defective, yielding a rejection rate of 0.69%.

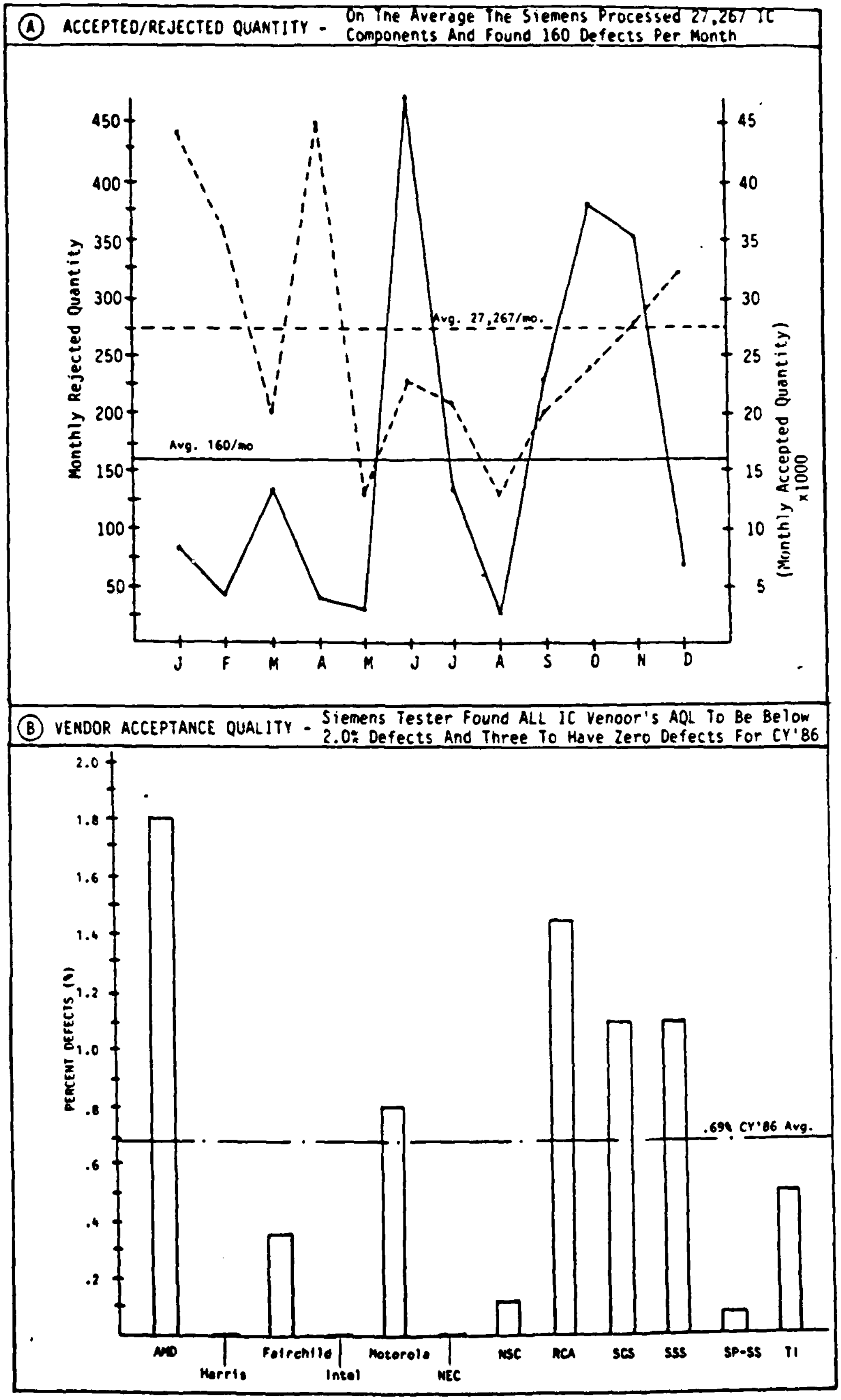


Figure 4 RESULTS OF ONE YEAR'S DATA - With an AQL of 0.69% Defective For Incoming ICs, Siemens Tester Fail To Provide An Adequate IRR.

- o Calculated labor costs for one operator of the integrated circuit equipment in Receiving Inspection in 1986 was $59,592.
- o Calculated cost savings in Component Level Test (that is troubleshooting, repair, retest and reinspection) in 1986 was $48,687.

The labor cost for the integrated circuit equipment operator in Receiving Inspection more than offset the cost savings for the detection and removal of defective integrated circuits in Component Level Test for a net annual loss of $10,905. In addition, a capital equipment/labor investment of $113,958 for the Siemens IC Tester, Trigon IC Handler and Siemens Program Library as well as project labor costs for Reliability Engineering and the Project Investigator makes the project unattractive for resuming an option 3 payment or productivity savings reward (PSR) from Tracor's major beneficiaries.

2.5 Program Management Plan

The Project Investigator responsible for reporting the results of this project is B. Hutchison, Quality Engineering. The coordination and earlier work performed in Phase 1 and Phase 2 was accomplished by P. Cook and G. Mills.

Those departments contributing direct support to the Receiving Inspection Component Testing effort include Reliability Engineering, Quality Engineering, Quality Control Inspection and Components Engineering (Reference Figure 5). The Component Testing Master Schedule for this project is shown in Figure 6.

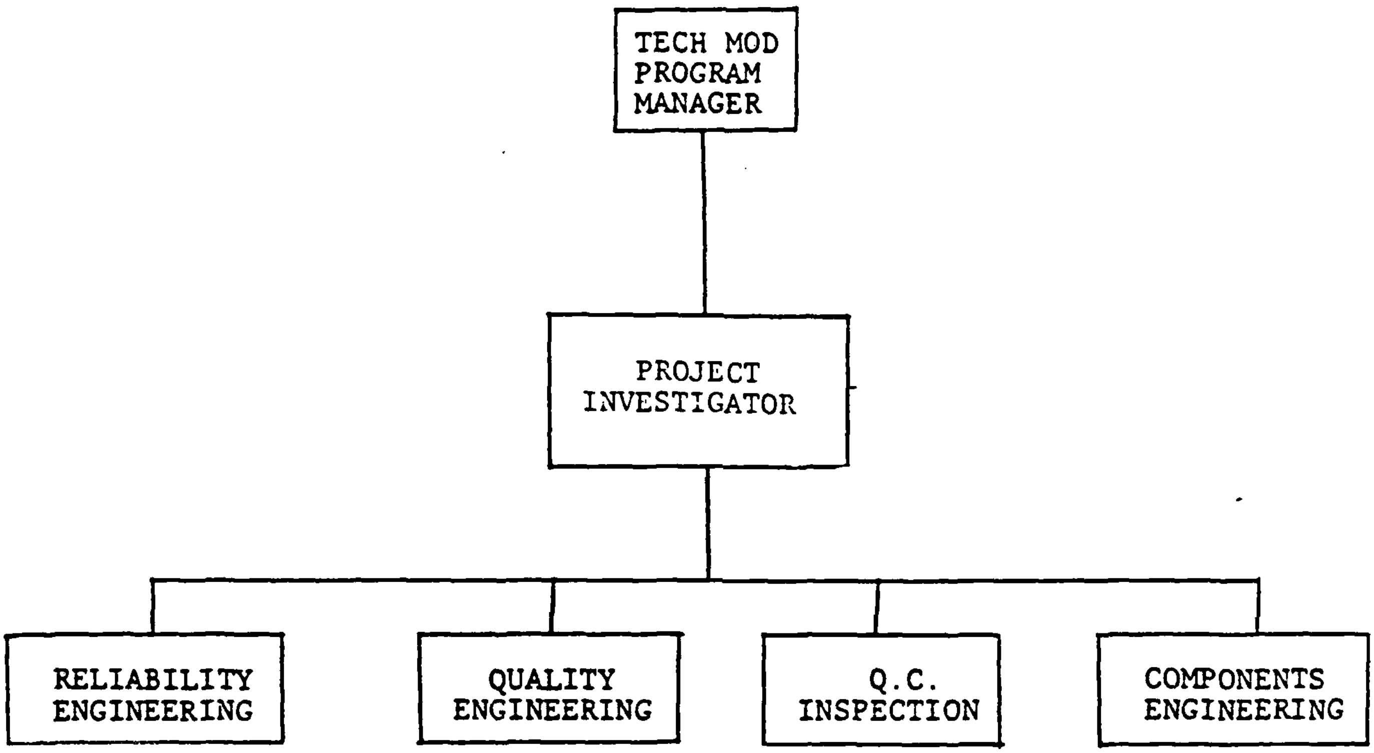


Figure 5 INDUSTRIAL TECH MOD RECEIVING INSPECTION
COMPONENT TESTING ORGANIZATION

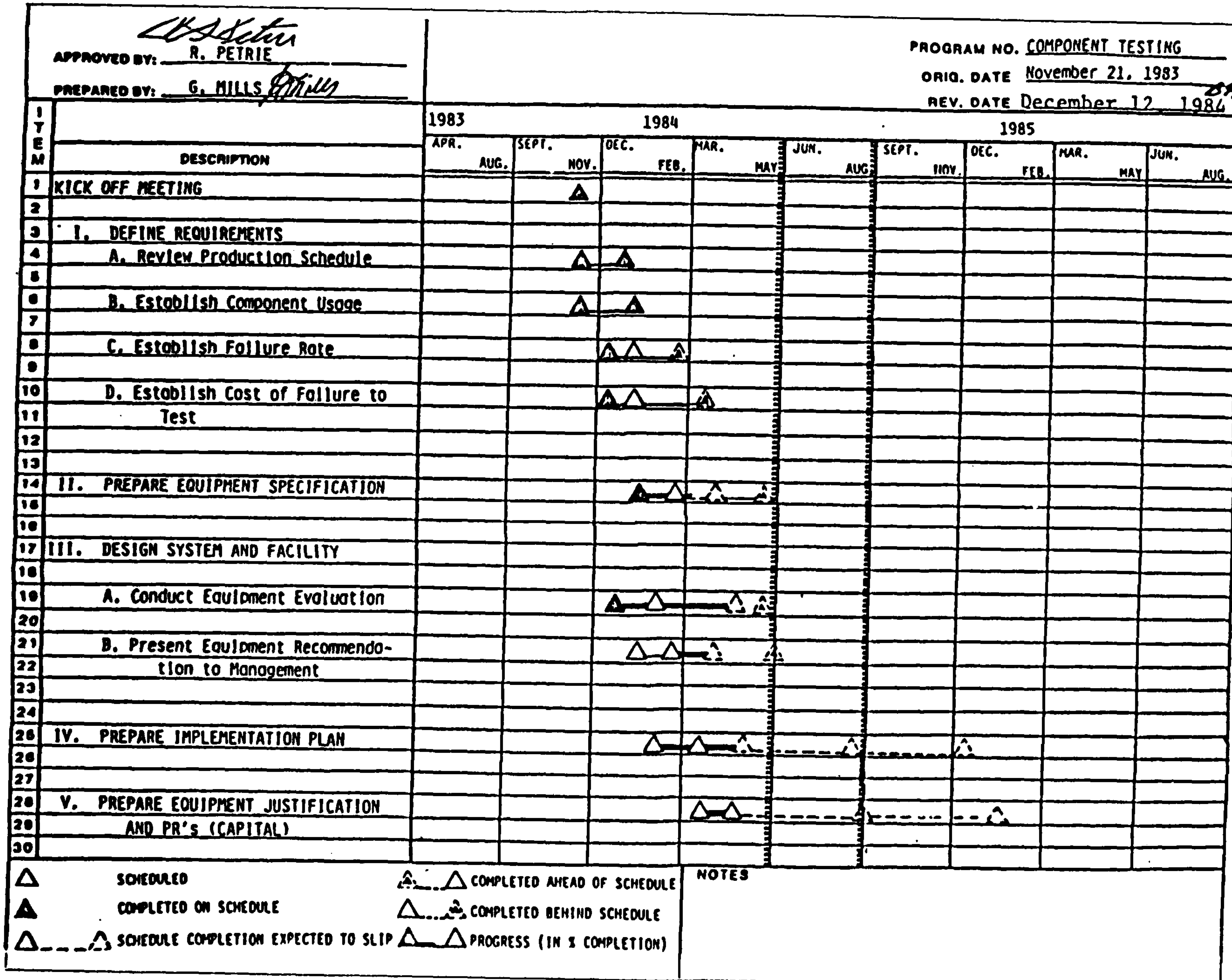


Figure 6 COMPONENT TESTING MASTER SCHEDULE

Tracor Aerospace

APPROVED BY: R. PETRIE

PREPARED BY: G. MILLS

PROGRAM NO. COMPONENT TESTING

ORIG. DATE November 21, 1983

REV. DATE December 12, 1984

ITEM	DESCRIPTION	1983 APR. AUG.	SEPT. NOV.	1984 DEC. FEB.	MAR. MAY	JUN. AUG.	SEPT. NOV.	1985 DEC. FEB.	MAR. MAY	JUN. AUG.
1	VI. PROCURE AND INSTALL EQUIPMENT									
2										
3										
4	VII. COST BENEFIT ANALYSIS									
5										
6	A. Establish Cost and Savings									
7	Elements									
8										
9	B. Financial Analysis									
10										
11										
12	VIII. PREPARE PROPOSAL									
13										
14										
15	IX. PROPOSAL SUBMITTAL									
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△ SCHEDULED

▲ COMPLETED ON SCHEDULE

△- - -△ SCHEDULE COMPLETION EXPECTED TO SLIP

△...△ COMPLETED AHEAD OF SCHEDULE

△...△ COMPLETED BEHIND SCHEDULE

△—△ PROGRESS (IN % COMPLETION)

NOTES

Figure 6 COMPONENT TESTING MASTER SCHEDULE (Cont.)

3.0 CONCLUSIONS

A comparison of the costs and projected savings leads to the conclusion that the overall costs exceed any financial benefit to Tracor. A simple comparison of detection cost in Receiving Inspection to potential savings in the factory results in a net cost to Tracor of $10,905. This does not take into account many other cost items of capitalization, programming, maintenance, etc.

Based upon this analysis Tracor recommends that the Component Testing Project be removed from further Industrial Tech Mod considerations.

APPENDIX A

IC TESTERS REVIEWED

Analog Devices
LTS-2000 Series Component Test System
LTS-2010 Analog Test System
LTS-2015 Benchtop Test Set
LTS-2500 Digital IC Test System

These benchtop systems are similar in cost and performance to the GenRad equipment.

AED
Digital IC Tester/Critique
- Parametric measurement capability is limited.

Datatron
Spectrum Series I Digital IC Test System
- Claims some AC parametric testing capability also.

Exatron
IC Testers, Model 510 and 2800
- These systems test using signature analysis rather than parametric measurement methods.

Eagle Test Systems
Model LS-1 Digital/Linear DC/AC Parametric Test Systems
- Up to 128 pins; difficult programming; very flexible; need for very high operator skill/difficult to set up.
- Subsequent redesigns are planned for 1985 and 1986.

Fairchild
Sentinal and Sentry Production LSI Test System
Series 20 IC Test System
Models V, VII, and VIII Logic Test Systems
- Fairchild systems are the standard against which others are judged. Very expensive/require dedicated staff.

GenRAD
Test System Seminar in Dallas, July 1984
Model 1731 Linear Benchtop IC Test System
Model 1732 Digital IC Test System
Model 1734M Memory IC Test System
- Good cost/performance value for memory testing.
The above GenRad test systems all have a very easy operator interface. They are excellent for general lab work but are not widely used for production environments.
Accuracy and stability not as high as some users require.
Model GR-16 VLSI general purpose multiple-cabinet top of the line system using PDP-11/34A computer.
- Very expensive, still being optimized.

Hewlett Packard
    Model 5045A Digital IC Test System
    Model 5046A Digital IC Test System
    - Both require some considerable expertise to program and interpret but they are easy to operate once set up. Some off-the-shelf software available, but used more by research labs and technical staff than for production operations.

Micro Control Corporation
    Model M-7 IC Memory Test System
    Model M-10B General LSI Test System
    - Uses signature analysis rather than full AC parametric test measurements.

Micro Component Technology
    Model IT-200 Integrated Circuit Tester
    Model 2000 Test System
    - Very high grade equipment, very costly, dedicated technical staff required for operation.

Semiconductor Test Technology
    Model EMT-200 Benchtop Memory Test System
    - Limited test sophistication/signature analysis method.

Siemens (Selected - offered most capability at least cost)
    Model 725 Digital IC Test System
    - competitive price with GenRad and Analog Devices
    - highest accuracy, stability/self-checking systems
    - large installed base, in use by many IC test house
    - relatively large pre-existing software library ...and at very low cost. Programs easily edited.

System Sales
    Model LSI-1 IC Test System
    - An ambitious but unproven low cost test system.

Teradyne
    Model J325 Analog Test System/laser trim tests
    Model J385A High Speed Production RAM Test System
    Model A360 Analog LSI Test System, very powerful, costly

IC HANDLERS REVIEWED

Control
Model H31D Handler

Daymark
Model 952/3 Handler
Model 1152
Model 1156/57

Delta
Model 8040 IC Handler

Exatron
Models 800B and 810C;
Model 2500 IC Handler

Micro Component Technology (MCT)
Model 2608E Ambient/Elevated IC Handler
Model 2608C Cold IC Handler
Model 3608AE Ambient/Elevated IC Handler
- The quality is extremely high but the hardware is very expensive and requires very high volume to achieve proper return on investment.
- Very difficult to make changes for IC package size, and production setups tend to be fixed configurations.

PAE
Model 3000 Series IC Handler
- Not widely used.

Symtek
Model 7191 ND IC Handlers
Related models

Trigon 2000 Series IC Handlers (Selected - offered most capability at least cost)

Model T-2070 Ambient/Elevated IC Handler selected as the best cost performance value: Witnessed several demonstrations at industry trade shows. Very easy to reset for IC package sizes. Excellent thermal control system, including a preheater system to increase throughput at elevated temperatures. Modular assembly to permit easy access for service work and board replacement.

EVALUATION CRITERIA

Functions/Test Cabability

- o Tester Capability
  - o Digital
  - o Analog/Linear
  - o Memory
  - o Microprocessors
  - o Full DC and/or AC parametric testing and data-logging ...vs comparative Signature Analytical methods
  - o Interface with standard Automatic Handlers
  - o Accuracy/Self Caibration and Test Modes
  - o Batch Memory for printed test summaries
  - o Datalog Printouts for device characterization and failure analysis
  - o Multiple Test Heads/Multiplexed operation
  - o Wide Industry Acceptance and large User Installed Base
  - o Supplier Stability in Marketplace

- o Device Automatic Handler Capabilities
  - o Number of IC Load Sticks
    - one
    - three
    - five
    - >five

  - o Bin Sorting Catagories
    - none
    - three
    - five
    - >five

  - o Temperature Operation
    - Ambient
    - Ambient-Hot
    - Cold, expensive, usually liquid nitrogen coolant

  - o Device Size Capability
    - 300 mil
    - 400 mil
    - 600 mil
    - micro adjustable for package variations
    - maximum number of device pins 16, 24, 40, 48, 60, 64, 128
  - o Wide Industry Acceptance and Use/Large Installation Base

- o Training Requirements/Staffing Needs
  - o Ease of use by Production Personnel
    - Operator training requirements
  - o Hardware and Programmer training requirements
    - Factory training
    - On-site training

  - o Most systems will require one or two dedicated personnel for hardware maintenance and of programming. Larger more complex production systems will requrie several dedicated staffers.

- o Availability of Off-The-Shelf Device Software
  - o Size and scope of existing device library
  - o Cost/Range of pre-existing device software
  - o Cost/Range of custom device software
    - - Custom Test programs for complex IC devices usually very expensive

Tester Procurement Cost
  - o Low, <30K
  - o Moderate, <100K
  - o High, <300K
  - o Very High, $300,000-$1,200,000

Handler Procurement Cost
  - o Low, <18K
  - o Moderate, <25K
  - o High, $25,000-$150,000

- o Maintainability/Parts Availability
  - o Off-the-shelf factory parts availability
  - o Factory/Field Service technical assistance
    - - telephone technical support
    - - on-site field service support

Siemens Model 725 Digital IC Tester

The Siemens 725 was chosen because of its relatively low cost, its very large installed user base...a function of industry confidence in overall performance and accuracy...and because of the strength and stability of Siemens itself to provide both factory and field technical support. Many suppliers in the Automatic Test Equipment industry have faced very serious financial problems in recent years. An earlier test system purchased by Tracor in the mid 1970's quickly became unusable and was scrapped when it was no longer supportable by the manufacturer. This costly lesson was an important consideration in the selection of a newer system for use by the Tracor Aerospace Receiving Inspection Department.

In addition, the IC test system selected needed to produce detailed, accurate and reproducible device-characterization data-log printouts. The Siemens 725 was ranked number 1 within the moderate price category. Comparative Signature Analysis test systems do not meet his criteria.

Trigon Model T-2070 IC Package Handler/Sorter

The handler selected needed to operate at both ambient and at elevated device test temperatures. The capability to handle 400 and 600 mil-wide IC packages as well as the standard 300 mil devices was desired to order to prevent premature obsolescence of the hardware. The Trigon is one of the fastest and easiest system to reconfigure for size. Microadjustments for device variation are also possible with this sytem. Automatic output bin sorting was mandatory. The capability to have more than one input stack was highly desirable in order to permit one operator to keep the machine running continuously when that was appropriate for large production runs. The high temperature system in the Trigon 2070 have a preheater section which effectively increases the test throughput over that which would otherwise be possible. The manufacturer offers factory training for operation and maintenance, spare parts, and even on-site field service through reps in many locations.